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Integrative Student Learning: An Effective Team Learning Activity in a Learner-Centered Paradigm

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Integrative Student Learning: An Effective Team Learning Activity in a Learner-Centered Paradigm

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ABSTRACT

Purpose: *An Integrative Student Learning (ISL) activity was developed with the intent to enhance the dynamic of student teamwork and enhance student learning by fostering critical-thinking skills, self-directed learning skills, and active learning.*

Case Study: *The ISL activity consists of three portions: teambuilding, teamwork, and a facilitator driven "closing the loop" feedback discussion. For teambuilding, a set of clue sheets or manufacturer's drug containers were distributed among student pairs who applied their pharmaceutical knowledge to identify two more student pairs with similar clues or drugs, thus building a team of six. For teamwork, each team completed online exams, composed of integrated pharmaceutical science questions with clinical correlates, using only selected online library resources. For the feedback discussion, facilitators evaluated student impressions, opened a discussion about the ISL activity, and provided feedback to teams' impressions and questions. This study describes three different ISL activities developed and implemented over three days with first year pharmacy students. Facilitators' interactions with students and three surveys indicated a majority of students preferred ISL over traditional team activities and over 90% agreed ISL activities promoted active learning, critical-thinking, self-directed learning, teamwork, and student confidence in online library searches.*

Conclusions: *The ISL activity has proven to be an effective learning activity that promotes teamwork and integration of didactic pharmaceutical sciences to enhance student learning of didactic materials and confidence in searching online library resources. It was found that all of this can be accomplished in a short amount of class time with a very reasonable amount of preparation.*

Introduction

Teamwork assignments and team learning are known to positively support student learning and generate productive learning outcomes that are superior to traditional individual learning tools. [1-5] The principle behind team learning is that students working together as a team are capable of achieving a higher level of learning than individual students alone. In a team, each individual member can bring a diverse set of knowledge, skills, experiences, and expertise to complement and support one another's strengths. [6] Since the success of each individual is tied to the success of the team, students can be motivated to help each other in a team. [7]

In the rapidly changing healthcare paradigm, employers expect recently graduated pharmacists to be effective team players able to manage team oriented tasks and responsibilities. While there are many factors that may prevent recently graduated pharmacists from possessing adequate teamwork skills, an obvious one is a lack of curricular intervention to promote teamwork skills among students. The Accreditation Council for Pharmacy Education (ACPE) states, in their Standard No. 13, that the college/school of pharmacy should address teamwork in their curriculum. [8] Therefore, it is critical to educate students at the school/college level to recognize the important role teamwork plays in the quality and productivity of assignments.

The idea of employing a learner-centered paradigm to facilitate student learning was largely initiated by Barr, Tagg, and Guskin in 1994-1995. [9-10] Since then, this new paradigm generated a series of productive discussions among faculty and academic leaders about the roles faculty play in facilitating student learning. As Doyle pointed out in his book "creating a learner-centered environment is the most important thing an educator can do to optimize students' learning." [11] Additionally, Huba and Freed suggested that educators should focus on student learning and, as a result, they must shift from a traditional teaching paradigm to a learner-centered paradigm. [12] The learner-centered paradigm has been defined as a model in which faculty coach and facilitate student learning, students are responsible for their learning, the classroom teaching is expanded beyond a single method to employ different teaching and learning tools, teamwork is the norm rather than an occasional curricular activity, and the focus is how students learn and how they apply their learning rather than how faculty teach. [11-14] Furthermore, in a learner-centered paradigm, students are more motivated and responsible for learning and more active in a teamwork manner than a teacher-centered paradigm.

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Similarly, faculty are more engaged in facilitating interactions and discussions among students; are encouraged to be innovative in their teaching and assessment; and they integrate more disciplines into their teaching. [11-14] These suggestions indicate that a shift in instructional methodologies in pharmacy education is needed to enhance student learning.

Weimer, in her book titled Learner-Centered Teaching, elegantly outlines five criteria to encourage faculty to apply a learner-centered pedagogy. These criteria were described further by Harris as i) balance of power (when faculty share his/her power with their students by providing more choices in regards to assignments or teaching methods); ii) function of content (when faculty let their students link their existing knowledge to the new knowledge); iii) teacher's role (when faculty's role is to coach); iv) responsibility for learning (motivate students to accept responsibility for their learning); and v) assessment (when faculty apply both formative and summative assessment to evaluate student learning and teaching effectiveness). [15-16]

It has been suggested that being able to conduct an effective literature search is an important skill that successful learners possess. By the same token, learners who are not familiar with literature searches impose upon themselves a high extraneous load by engaging in irrelevant search activities. [17] Therefore, it is imperative to train and encourage students to conduct literature searches, and if feasible, in the early phase of the didactic curriculum. This is particularly important for the Introductory and Advanced Pharmacy Practice Experiences (IPPE and APPE) sites because students at these sites often need to use remote library resources to complete daily experiential assignments. As technology allows information to become more integrated and accessible, the demand to access on-line libraries is increasing for both students and preceptors. [18-19] Indeed, activities that encourage students to use online library resources promote student self-directed learning as students are encouraged to use their own knowledge to explore the available resources to enhance their learning. [20]

Our School of Pharmacy follows a learner-centered paradigm that delivers a 3-year block curriculum. One two-week block of content is taught at a time and students take exams following each block. The first two professional years are comprised of a series of two-week didactic blocks and a few concurrent longitudinal blocks, including IPPE blocks. This curricular design supports an active learning environment in which students are encouraged to be active learners both individually and in teams, integrating both scientific and clinical knowledge to solve the problem at hand. [21-24]. A significant component of our first professional (P1) year curriculum consists of pharmaceutical sciences combined with clinical correlations.

In the present study, we developed a novel activity, the Integrative Student Learning (ISL), to promote student learning in a teamwork environment in a series of pharmaceutical science topics. The ISL also encourages students to utilize online library resources to find accurate and relevant information. In addition, we believed by allowing students to generate exam questions, they would enhance their learning of didactic materials and gain a sense of what faculty face in writing effective exam questions. The idea of ISL stems from important features of a learner-centered paradigm namely facilitating and supporting an interactive teamwork dynamic, promoting critical-thinking, active learning skills, and self directed learning, and concurrently promoting and assessing student learning. [11-14]

The desired outcomes for the ISL activities were to:

1. Enhance the dynamic of student teamwork by building an integrative learning environment; assisting students in gaining insight into their strengths and weaknesses; creating a cooperative and supportive learning environment; and accommodating diverse learning styles.
2. Enhance student learning by fostering critical-thinking skills; self-directed learning skills; active learning; knowledge retention, drug information knowledge base development; and effectiveness and confidence in literature searches.

Integrative Student Learning

The role of faculty at a School or College with a learner-centered paradigm is "to coach and facilitate" rather than being the primary information giver. [11-14] This role has been applied to the ISL activity. The ISL activity was designed with three main parts (Figure 1): teambuilding, teamwork, and a facilitator driven "closing the loop" feedback discussion. For the teambuilding portion, either a set of clue sheets or manufacturer's drug containers were distributed among student pairs who utilized their pharmaceutical knowledge to identify two other student pairs with related clues or drugs to build a team. For the teamwork portion, each team completed online exams, composed of integrated pharmaceutical science questions with clinical correlations. During the exam, each team was allowed to use only selected online library resources. For the "closing the loop" feedback discussion, facilitators (2 faculty members and 3 pharmacist residents) discussed the outcome of the ISL activity, evaluated the student impressions of the ISL activity, and

answered any student questions about the materials included in the activity.

Our initial pilot ISL observation from a pharmaceutics course, which was similar to ISL day 1 in this presented study, indicated that the ISL activity was perceived by students as an effective learning activity to promote and assess student learning (poster presented in the 111th annual AACP meeting in Seattle, WA). [24] Therefore, the pilot ISL activity was expanded to be used over 3 days (within a 24-days span in our curriculum) during a compounding course.

IRB approval was sought and granted by the Pacific University Institutional Research Board for the completion of this study. In addition, the authors report no conflicts of interest in this study.

During the morning of each ISL day, one third of our P1 pharmacy students were learning compounding skills in the compounding lab while the other two thirds of students were completing an ISL activity in a classroom. In the afternoon, the groups rotated allowing the remaining third of the students to complete the same ISL activity that the others completed earlier.

In this study we implemented the following 3 ISL activities, over three separate days, for the P1 students:

1. Student teams completed ISL activities that were generated by faculty (1st day)
2. Student teams generated their own ISL activities (2nd day)
3. Student teams completed ISL activities that were generated by their peers (3rd day)

1. Student teams completed ISL activities that were generated by faculty (1st day)

For the teambuilding portion of this ISL activity, we utilized three drugs (furosemide, lisinopril, and simvastatin) with 3 clue sheets per drug. Each clue sheet had 3-4 clinical and pharmaceutical science clues about the drug. A clue sheet was given to each student pair (Figure 1). In order to encourage them to use their own knowledge base of drug information, the student pairs were not allowed to have access to any online library resources or class materials. The pairs actively interacted with others to identify two more student pairs with clue sheets alluding to a shared drug. These 3 pairs built a team of six students that then began the teamwork portion of the ISL activity. The team was directed to complete an online (Blackboard; Blackboard Inc., Washington, DC) exam which included 11 integrated pharmaceutical sciences questions specifically designed for their identified drug. An example of a typical ISL exam question generated by faculty is presented in Appendix 1.

The student teams were encouraged to discuss each exam question and were required to submit their responses online for automatic grading. During the exam activity, students were allowed to use the following faculty approved online library resources: AccessPharmacy; International Pharmaceutical Abstracts; MEDLINE-PubMed; Lexi-Comp Online; Stat!Ref.; and Drug Facts and Comparisons. In addition, an electronic version of the official package insert for each drug was provided. No other online resources, including lecture notes, were allowed to be used during the ISL exams. The above library resources were permitted to provide a benchmark for future use as students come across other resources that may or may not have the same level of accuracy. No automated monitoring or "lockdown" software was used during exams. Compliance, however, was encouraged by requiring teams to cite any references used to answer the questions and by facilitators randomly monitoring team rooms. Students were given 60 minutes to complete the exam, allowing time for thorough team discussions and exam submission. Fifteen teams participated in this activity. After building their team from the original 3 clue sheets, each team completed at least 2 different ISL exams on the same day. After completion, student teams submitted their responses to the faculty member(s) for review. In order to explore students' impressions and perceptions about the ISL activity, an anonymous survey was implemented and completed by 65 students (70% response rate) at the conclusion of the ISL activities.

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2. Student teams generated their own ISL activity (2nd day)

In the 2nd ISL day, students were asked to build at least one ISL activity which included clue sheets and exam questions with an explanation for each correct answer. In order to complete teambuilding, we spread out different manufacturer's drug containers across the front of the classroom. Two students as a pair were asked to find two other student pairs with a common class/type of drug. A group of 6 students with a common drug class built a small team and received a single drug name for which to generate an ISL activity during the teamwork section. In order to produce cohesive and consistent activities, a series of criteria and guidelines were provided to each team. These criteria and guidelines required students to: i) write three clue sheets; ii) write 3 clues on each sheet (examples of our past clue sheets were provided); iii) provide the chemical structure of their assigned drug on one of the clue sheets; iv) write six or more effective exam questions (we provided a 30 min introduction on how to write effective exam questions along with an exam question tips sheet (Appendix 2)); v) integrate

as many clinical and pharmaceutical sciences topics as possible in their activities; vi) access the online library resources and the official package inserts; vii) create an exam key with an explanation of the correct answer; and viii) provide a list of library resources they used during the generation of the ISL activities. Fifteen teams participated in this ISL activity.

Each team was given 75 minutes to complete and submit their ISL activity. The following drug names were given to student teams to build their ISL activities: levothyroxine sodium; escitalopram oxalate; amlodipine besylate; metformin; cetirizine hydrochloride; fluticasone propionate and salmeterol inhaler; clopidogrel bisulfate; and alendronate sodium. The intent of using these drugs was to expose students to different dosage forms with different mechanisms of action. An example of a typical ISL exam question generated by a student team is presented in Appendix 1. By the conclusion of the 2nd day, we examined each ISL activity to evaluate how well they aligned with the above criteria. In addition, we reviewed the exam questions (and explanation for each correct answer) to make sure that they were accurate and followed the criteria for writing effective exam questions. An anonymous survey was implemented and completed by 57 students (61% response rate) after the conclusion of this ISL activity.

3. *Student teams completed ISL activity that was generated by their peers (3rd day)*

The process for this activity was similar to the 1st day (Figure 1), except the clue sheets for teambuilding, and exams for teamwork were selected from the best of the student generated activities from the 2nd day. In addition, we made sure that no student worked on any ISL activity that was produced by his/her team during the 2nd day. Four drugs were used: levothyroxine sodium, amlodipine besylate, metformin, and alendronate sodium. Student teams were given 60 minutes to complete the exam questions. An anonymous survey was implemented and completed by 69 students (74% respondent rate) after the conclusion of the 3rd day.

During the 1st and 3rd days, at the conclusion of activities and upon submission of the ISL exam, student teams were able to see an explanation for each correct exam answer. At the conclusion of each ISL day a 20-minute "closing the loop" feedback discussion was implemented in which facilitators led discussions with students. This immediate feedback process was intentionally implemented to evaluate the effectiveness of the ISL activities, stimulate student discussion, and to allow students to reflect on what their team learned during the implemented activities. Three pharmacist residents from three different pharmacy programs, who were completing their PGY1 residencies, assisted us in facilitating the three ISL days. While they were not involved with the design of the study, their input, coaching assistance to students, and conducting the immediate feedback process at the conclusion of each ISL day, assisted us in making the entire ISL activity a productive learning experience for students.

Evidence of Student Learning

In this study we used a total of three surveys to assess the intended outcomes. We used the online tool Blackboard to electronically and anonymously implement all three surveys. Students were given 24 hours to complete each survey. Based on our desired outcomes, the surveys were organized into two sections to assess:

1. Dynamic of student teamwork by: building an integrative learning environment; assisting students in gaining insight into their strengths and weaknesses; creating a cooperative and supportive learning environment; and accommodating diverse learning styles.
2. Student learning by: evaluating critical-thinking skills; self-directed learning skills; active learning; knowledge retention and knowledge base of drug information; and effectiveness and confidence in literature searches.

The following definitions were included in the survey questions to assure that we collected reliable and consistent student perceptions in regards to survey questions.
Dynamic of student teamwork: You and your team members effectively communicate to review and identify steps needed to find accurate information for the questions.
Integrative learning environment: A learning environment that integrates pharmaceutical sciences topics (pharmacology, medicinal chemistry, top 200, biochemistry, pharmacokinetics, pharmaceutics, and calculations).
Critical-thinking skills: Intellectual skills to critically interpret and evaluate a concept or a problem in order to synthesize or find an accurate answer to a question. [22-23]
Self-directed learning: Students are self-guided and know how to use their knowledge and resources to complete assignments. [22-23, 25]
Active learning: Students utilize and refer to their own knowledge to answer a question and also actively seek and explore other resources and gather relevant information to improve or find a better answer. [8, 22-23, 26]
Effective exam questions: Questions that have no grammatical or spelling problems, are concise, and assess student learning.

Quantitative responses were based on a Likert scale: "Strongly Agree," "Agree," "Neutral," "Disagree" and

"Strongly Disagree." A combination score of "Strongly Agree" and "Agree" equal to or greater than 75% was a desired target level in our assessment activities. The final student survey also included the following two qualitative questions:

1. Describe how the ISL activities assisted you in your learning.
2. Which ISL day demonstrated your best work? Why?

Evidence of Student Learning from ISL *1st Day*
Table 1 indicates the assessment results that we received from the 1st day that ISL was implemented. As shown by the significant number of respondents (≥95%) who agreed with the questions presented in this table, the ISL was a productive curricular team activity. Our data showed that 100% of students believed the ISL activity built an integrative learning environment and 95% of students believed the ISL activity assessed their knowledge retention from the P1 curriculum.

Evidence of Student Learning from ISL *2nd Day*
The ISL 2nd day was dedicated exclusively to the generation of an ISL activity by student teams. Table 2 shows the results that the second ISL day produced. While a few data presented in Table 2 were similar to data presented in Table 1, one can see that a majority of students (≥91%) stated that this ISL day assisted students in gaining insights into their strengths and weaknesses and learning how to write effective exam questions. In addition, 96% stated that ISL promoted their self-directed learning skills.

Evidence of Student Learning from ISL 3rd Day
Since the ISL 3rd day completed our study, we assessed many components of the entire ISL activity. The results of this comprehensive assessment are presented in Table 3. A large majority of students (≥ 93%) agreed that the ISL activity improved their knowledge base of drug information, created a cooperative learning environment in which student learning of didactic materials was promoted, increased student confidence in searching literature, and they made progress in enhancing their drug information skills. Additionally, students believed that the entire ISL activity was a well-designed integrated curricular activity and provided a variety of innovative teaching and learning techniques to create an optimal learning environment.

We asked students to be self-reflective by comparing and contrasting all 3 days of ISL activities and identifying the day that demonstrated their "best work", explaining their choice. Our data indicated that 33, 45, and 22% of students selected day 1, 2, and 3, respectively, as their best work. The most frequent comment that was given for the selection of ISL 2nd day was enhanced student learning during the generation of exam questions. In the qualitative questions, students provided many comments in regards to the benefits they received from completing the ISL activities. As evidenced in Table 4, learning how to use library resources, enhancing teamwork skills, and identifying strengths and weaknesses assisted students in their learning.

Finally, we were interested in knowing the format students preferred when learning didactic materials. We compared our ISL activities with traditional lecture presentations and other team activities (group assignments, projects, presentation, etc.) that are often and routinely applied within our curriculum. Respondents indicated that they (N = 65) preferred to learn materials: in a traditional faculty lecture presentation format then *combining* that with an ISL activity (60%); in a traditional faculty lecture presentation format combining that with a traditional group activity (23%); only in an ISL format activity (14%); and only in a traditional faculty lecture presentation (3%).

In order to reward student teamwork and assess their effectiveness in finding accurate responses to the ISL exam questions, we graded all of the ISL activities. The mean score ± SD for ISL 1st and 3rd days exams were 94% ± 8.4% and 97% ± 4.0%, respectively (Note: A 100% ISL exam score corresponded to 6 points being added to a student's compounding course score). The 2nd ISL day assessment was solely based on the quality of the ISL activity that student teams generated. Criteria for grading ISL 2nd day were i) to give 0.4 points to each well-written clue sheet (up to a total 1.2 points); ii) to give 0.8 points to each high quality ISL question (up to a total 4.8 points). Students were encouraged to write more ISL questions (up to 12 questions) to increase their chance of receiving a maximum of 4.8 points for writing high quality questions. Based on accurately meeting the above criteria, all teams received full points (100% or 6 points).

Facilitators' Evaluations of Student Learning:
Since three pharmacist residents experienced a direct observation of implementing the ISL activity, we asked them to evaluate the effectiveness of the ISL activity. A series of comments were provided which included: "it was an effective activity to promote the desired outcomes outlined in the study"; "the ISL activity was a very powerful and unique tool that allowed students to integrate basic knowledge into an interactive exercise in order to improve their teamwork dynamics, critical thinking skills, and self-directed learning"; "the ISL activity in the classroom was a successful and innovative way to facilitate student learning"; "it was an effective tool to promote the desired behavioral outcomes outlined in the study"; "I was impressed with the unique way

that the program was designed"; and "I believe that the ISL promoted learning as well as assessed learning of the students".

Discussion

Student Learning

The data presented in Tables 1-3 and our direct observations consistently indicated that the ISL activity promoted student active learning, self-directed learning, and promoted student critical-thinking skills. Students learn better if they are actively engaged in their learning. [8, 22-23, 26] One way of creating an environment for active learning is to generate a team dynamic and promote teamwork. [5&27] Many colleges/schools of pharmacy and pharmacy educators in the U.S. are actively engaged in learning processes that assist students in developing critical thinking skills. [22-23, 28-29] Critical-thinking skills are important skills that assist students in analyzing and evaluating problems to find accurate information in order to solve a problem. [22-23, 30] The American Association of Colleges of Pharmacy's (AACP) Center for the Advancement of Pharmaceutical Care (CAPE) and ACPE emphasize the importance of critical-thinking skills in pharmacy education which indicates that with the quickly evolving pharmacy profession, colleges/schools of pharmacy are accountable to provide an effective curriculum and learning environment where students can develop critical-thinking skills. [8&31]

The links between active learning, critical-thinking, and self-directed learning in enhancing students' knowledge base of drug information are apparent in the results of the comprehensive survey that we administered after the conclusion of the ISL 3rd day. For instance, a significant number of students (96%) mentioned that in working with the ISL activities and comparing, analyzing, and selecting the right answers, they improved their knowledge base of drug information (Table 3). Garrison defines self-directed students as learners who are motivated to learn, believe they are capable of learning, have a great awareness of their responsibility in constructing and confirming meaningful learning outcomes, and are more likely to be high achievers. [25] Both ACPE (Standard 12) [8] and our internal curricular instructional strategy [22-23] emphasize the need for students to possess self-directed learning skills. In addition, ACPE Standard No. 29 emphasizes the importance of effective and efficient use of the library and educational resources by students. [8] Our data indicated that students increased their confidence in completing literature searches to find accurate information and they made progress in enhancing their drug information (Table 3). In addition, the qualitative results presented in Table 4 confirm the above quantitative results.

Assessment of student learning

Our findings showed students believed the ISL activities assessed their knowledge retention from the P1 curriculum (Table 1 and 2) and created an environment where they as learners, gained insights into their strengths and weaknesses (Table 2). Although we did not have qualitative questions to explain how the ISL activity assisted students with their strengths and weaknesses, we believe identifying strengths and weaknesses provided direction to students as to what areas they needed to maintain and what areas they needed to focus on improving. The most compelling evidence of the role the ISL activities played in the assessment of student learning was provided in the comprehensive survey when 94% of students believed the ISL activities assessed and promoted their learning (Table 3). One of the important components of a learner-centered paradigm is to find an assessment tool that both assesses and promotes student learning because assessment is an integral component of student learning. [12] For instance, implementation of the ISL activity assisted faculty in monitoring how students used the online resources to answer a question and encouraged students to utilize the online resources to learn a new concept.

It has been suggested that student learning results that are solely based on student perception may not accurately reflect the intended learning outcomes. [32] Therefore, we organized "closing the loop" feedback discussions to immediately evaluate student learning. During each of the three 20-minute "closing the loop" feedback discussions, facilitators (2 faculty and 3 PharmD residents) observed interactive and productive student learning and discussions with an apparent impact from the ISL activities.

Students writing effective exam questions

Too often students hold faculty responsible for "rigorous and unfair" exam questions. Student exam writing training can assist students in gaining insight into the challenges that faculty face in their assessment techniques. We hypothesized that exam writing training could enhance student learning as one needs to learn a topic well to write an effective exam question for that particular topic. Therefore, we decided to provide basic exam writing training to students (Appendix 2) and ask them to generate an ISL activity. Our data indicated that 91% of students agreed that the generation of ISL activities assisted them in learning how to write effective exam questions (Table 2) and 97% stated that the ISL activities built an integrative learning environment (Table 2). Student self-reflection is a unique skill in that while it assists students in reflecting on how and why they have learned a subject, it also assists faculty in assessing what students have learned. [22-23, 33] Indeed, in the self-reflective section of the

survey on the 3rd day, 45% of students selected the 2nd day as their best work. From one of the qualitative assessment questions from the conclusion of the ISL 2nd day, we observed that the ISL 2nd day activities promoted student appreciation for the time and effort faculty put into creating their examinations. We believe the ISL activity in the 2nd day may smooth the student transition to the P2 year, which contains primarily clinical courses using exam questions that are not always black and white.

Interestingly, the majority of students (60%) stated that they would prefer to learn materials in a traditional faculty lecture presentation format *combined* with an ISL activity. This indicates learning that students acquire from an ISL activity can extend and complement what students learn from traditional lecture-based learning.

Finally, our results reveal that many components of our study matched well to a few components of a learner-centered paradigm. For instance, we found that in the ISL activity, student active learning, critical thinking, self-directed learning, cooperative and supportive learning, and faculty's coaching role were similar to what a learner-centered paradigm supports and promotes. Based on our observations, these similar components are generated due to teamwork, a self-managed learning process, a shift of knowledge transmission to knowledge application, and active student engagement. These similar data suggest that employment of the ISL activity may provide a smooth transition from a teacher-centered environment to a learner–centered environment, particularly in pharmacy education.

Implications and Strategies for Success

The following strategies were carefully followed to successfully implement the three ISL activities: providing clear, measurable, and feasible goals; a thorough communication plan; a well-designed structure; and generating an assessment plan to evaluate the outcomes. It is equally important to assign at least 20 minutes, at the conclusion of each ISL activity, to not only provide immediate feedback and evaluate the effectiveness of the ISL activity, but also to open a discussion about students' impressions and learning. While we were fortunate to have three pharmacist residents available to assist the 20-minute the feedback discussions, one faculty member can manage to complete an entire ISL activity.

For an average class size of 70 students, use of more than 4 different drugs is not recommended because too many clue sheets make the matching and teambuilding processes (Figure 1) complicated and time consuming.

There are a few barriers to employing the presented ISL activity. First, not all PharmD programs are equipped with breakout rooms to easily accommodate teamwork. Second, a traditional curriculum where faculty members teach 1 hour on any given day may not provide adequate time for students to complete an ISL activity. Third, a lack of online library resources may make the implementation of an ISL activity difficult and time consuming. Fourth, students were strongly encouraged to share responsibilities and access different online library resources, however, a few students may have focused on only one specific library resource. It is worth addressing that our study did not include any design to link the ISL activities outcomes with any comprehensive final examination. While this can be considered as a study limitation, our direct and immediate observations from the "closing the loop" feedback discussions, clear survey questions, facilitators' observation and feedback, and consistent compelling results from three different implemented surveys support the value of this activity in promoting student learning.

Our direct observations of each ISL activity demonstrated that the teamwork section, during the matching process of clue sheets (Figure 1), had a twofold function. One function was to promote student learning by facilitating students' discussions about integrated pharmaceutical topics. The other function was to allow students to build their own team based on a curricular activity. Therefore, in any teamwork activity, one can utilize the unique teambuilding process of the ISL activity to build new student teams.

In order to produce integrative ISL activities, one can include clue sheets and exam questions that encompass materials from the past courses that have been delivered. Because the ISL activity is a self-directed learning process, immediately providing answers to submitted questions can assist students in identifying their strengths and weaknesses and promote team discussion about the materials covered in the exam. Finally, the ISL activity can be viewed as a supplemental tool to other curricular activities in which only a portion of students can participate at a time (for instance in our case, 1/3 of students were learning compounding skills in a compounding lab and the other 2/3 were engaged in an ISL activity).

Future Research

Since our data indicated that the ISL activity assisted students in assessing their knowledge retention (Table 2 and 3), one could confirm this student perception by assessing student learning of topics that were delivered during the ISL activity in a final or end of year examination. In other words, assessing the long term effect of the ISL activity is desirable. In addition,

the ISL activity can be implemented in other didactic academic years (beyond P1 year curriculum) to see whether the ISL activity is applicable to clinical science courses. Although the ISL activity did not include the well-established team-based learning (TBL) standard phases [34], it would be interesting to compare these two team learning processes in order to identify benefits, differences, challenges, and similarities in regards to student learning, faculty and student buy-in, self-directed learning, and knowledge application.

Summary

The survey results and our direct observations indicated that the ISL activities facilitated teamwork, increased team dynamics, and assessed and promoted student learning, all of which are important components of a learner-centered paradigm. A significant number of students indicated that their critical-thinking, active learning, self-directed learning, and knowledge base of drug information were promoted by the ISL activities. In addition, students developed exam writing skills and increased their confidence in searching online library resources. As a result of our positive experience, and the students' affirmative feedback for the effectiveness of the ISL activity, we have incorporated three ISL days into our P1 curriculum.

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Figure 1. Overview of an ISL activity with 3 typical "clue sheets"

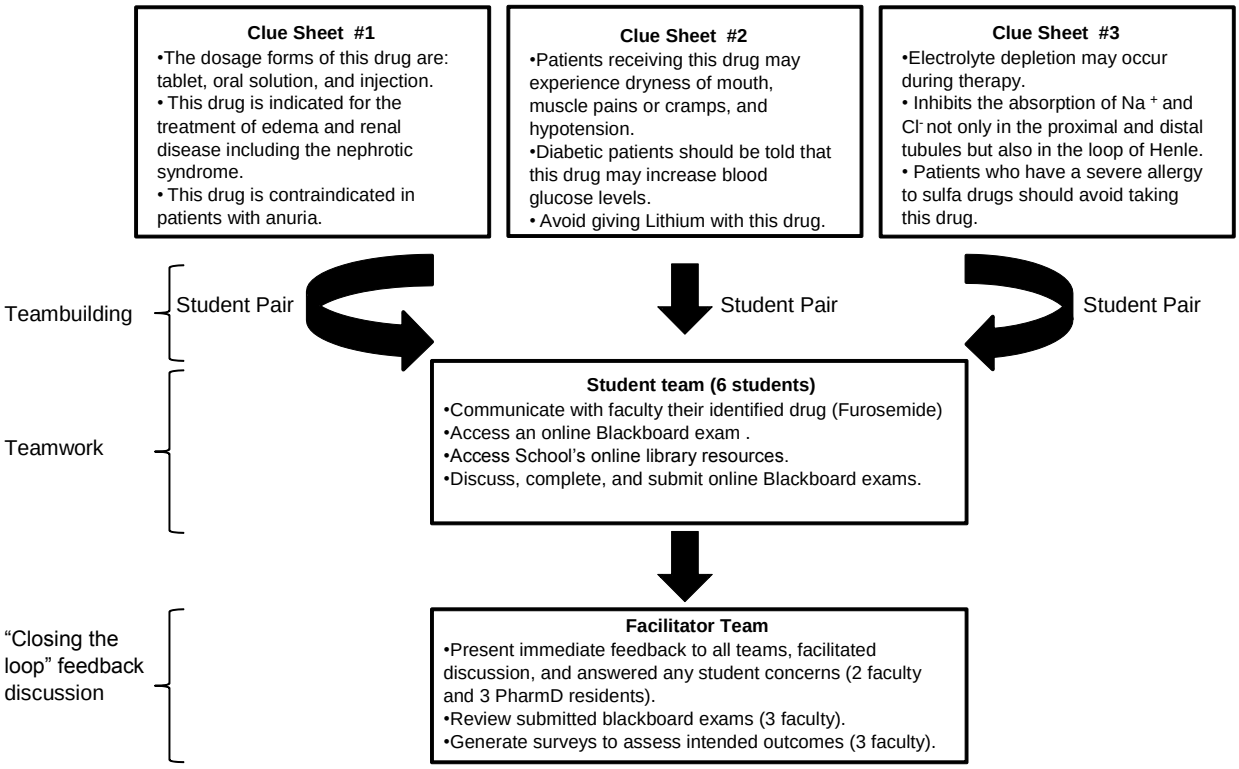

Table 1. Student responses to ISL survey's quantitative questions. Data from ISL 1st day. N = 65; Respondent Rate = 70%

Survey Questions	Student Responses (%)	
	Strongly Agree + Agree	Neutral
1. The ISL activity increased the dynamic of student teamwork.	98	2
2. The ISL activity created a team dynamic to accommodate diverse learning styles.	97	3
3. The ISL activity built an integrative learning environment.	100	0
4. The ISL activity assessed your knowledge retention from the P1 curriculum.	95	5
5. The ISL activities promoted your active learning.	98	2
6. The ISL activities promoted your critical-thinking skills.*	96	2
7. The ISL activities encouraged you to do literature searches to find answers to questions.	98	2

*2% of students disagreed with this statement.

Table 2. Student responses to ISL survey's quantitative questions. Data from ISL 2nd day. N = 57; Respondent Rate = 61%

Survey Questions	Student Responses (%)	
	Strongly Agree + Agree	Neutral
1. The ISL activity increased the dynamic of student teamwork.*	95	3
2. The ISL activity built an integrative learning environment.	97	3
3. The ISL activity created an environment where students, as learners, gained insights into their strengths and weaknesses in building the integrated topics.	96	4
4. The generation of today's ISL activity assisted you in learning how to write effective exam questions.	91	9
5. One of the ISL goals was to assess your knowledge retention from the P1 curriculum. You believe the ISL activities accomplished this goal.	86	14
6. The ISL activities promoted your active learning.	97	3
7.The ISL activities promoted your critical-thinking skills.	93	7
8. The ISL activities encouraged you to do literature searches to generate exam questions.	100	0
9. The generation of today's ISL activity promoted your self-directed learning skills.	96	4

*2% of students disagreed with this statement.

Table 3. Student responses to ISL survey's quantitative questions. Data from ISL 3rd day. N = 69; Respondent Rate = 74%

Survey Questions	Student Responses (%)	
	Strongly Agree + Agree	Neutral
1. In working with the ISL activities during the last 3 days and comparing, analyzing, and selecting the right answers, you believe you have improved your knowledge base of drug information.	96	4
2. The ISL activities facilitated your learning of the didactic materials.	93	7
3. Confidence in literature search is an asset to your learning and your future job as pharmacist. Because of literature searches that you did during the ISL activities you feel confident to do literature searches to find accurate information.	96	4
4. One of the important components of a learner-centered environment is to use an assessment tool to assess and promote student learning. You believe the ISL activities not only assessed but also promoted your learning.	94	6
5. You believe by searching and utilizing library resources you have made progress in enhancing your drug information.*	93	4
6. You believe the entire ISL activity created a cooperative learning environment where you not only enhanced your learning but also enhanced and supported each other's learning	96	4
7. The entire ISL activity provided a variety of innovative teaching and learning techniques to create an optimal learning environment for students.	97	3

*3% of students disagreed with this statement.

Table 4. A summary of students' responses in describing how the ISL activities assisted students in their learning.

Assisted me in becoming more fluent and adept at using library search resources and assisted me in listening to the input of my peers regarding ISL questions.
ISL activities helped me to become more familiar with the different databases available to me and also integrated what I have learned in the different blocks thus far.
When we were able to make our own test questions, it allowed for us to use critical thinking skills much better, making the learning process much more informative. It helps us go over important medications and key consultation details.
The ISL design forced us all to work together to find answers. Also, it was productive to form these random groups. During the course of these activities I met several classmates I had never spoken with before.
ISL certainly helped me review my drug information skills, which was appreciated because I haven't really had to use them in a while. ISL also made me realize my strengths and weaknesses that I need to improve upon to make me a better practitioner. It made me "jog my memory" and realize that I need to review my old notes!
I thought that the ISL activities were good at reinforcing us to use our credible sources for researching drugs and I thought that the ISL activities definitely encouraged group work and facilitated us using our previously learned information.
Learned clinical relevance to a drug; met people I would not otherwise have met; provided a different method to learning. It is successful because you have to change the way you think, instead of just sitting in class and taking in the information being lectured.
It assisted me in learning to use the database. I have a difficult time using databases and it forces me to learn to use it quickly to keep up with the group. It also assists me in reading material carefully.

Appendix 1

Two typical ISL exam questions and their answers that were generated by faculty (question 1) and students (question 2) during the 1st and 2nd days, respectively.

1. A physician calls you and wants to prescribe Bumetanide (tablet) for 10 days instead of Furosemide. His patient took his last Furosemide (tablet, 20mg/d) yesterday. Which of the following dose conversions is true to calculate the therapeutic equivalent dose of Bumetanide for this patient? (Available Bumetanide tablet strengths on the market are: 0.5mg, 1mg, and 2mg).

    a. You need to fill 10 x 0.5mg tablets
    b. You need to fill 20 x 0.5mg tablets
    c. You need to fill 40 x 1 mg tablets
    d. You need to fill 200 x 2mg tablets
    e. You cannot replace Furosemide with Bumetanide.

A is correct. 1mg of Bumetanide equals to 40 mg Furosemide (therefore, 0.5mg should equal to 20 mg). Never assume since a few drugs are in the same category (for instance loop diuretics), they should have equivalence dosing pattern.

2. Amlodipine formulated as an oral suspension for pediatric administration and is stable for the following days:

    a. 14 days at room temperature, 24 days refrigerated.
    b. 3 days at room temperature, 7 days refrigerated.
    c. 56 days at room temperature, 91 days refrigerated.
    d. 30 day at room temperature, 60 days refrigerated

C is correct. In the Extemporaneous Preparations section of Pediatric administration, the answer is listed for oral suspension. This is good information to know for creating the label for pediatric dosing.

Appendix 2: Exam Writing Tips Sheet

The goals of an exam are not only to assess student's strengths and weaknesses but also to promote student learning by encouraging and motivating students to study. Therefore, in writing an exam, you should focus on important areas that you value and avoid irrelevant concepts.

1. **Correct *vs* Best-Answer**
   It is important for item writers to keep in mind the distinction between items in which only one choice is correct, and items in which more than one choice may be technically correct but only one is clearly the best answer. In writing best-answer items, word the question in a way that clearly indicates that only one choice is preferred. EX: The major goal of raising the legal drinking age is to: 1) reduce driving fatalities and injuries. 2) reduce roadside litter. Etc

2. **Make it clear and concise**
   Present the exam question as clearly and succinctly as possible. Leave out nonessential information, but make sure to include all of the information needed to identify the correct answer. Nothing is more painful than a non clear exam question.

3. **Test, don't teach**
   Extraneous factual or descriptive information can delay the candidate's progress through the examination and may tip off the correct answer to another item.

4. **Build a consistent structure**
   All choices should be parallel in concept, length, grammar, and structure. Remove clues that make it easy for the candidate to detect the correct answer without having the knowledge or skill that the item is intended to measure.

5. **Avoid distractors that stick out**
   Distractors should always be plausible. Avoid using distractors that even the most uninformed candidate would recognize as being incorrect. Note that the use of humorous or absurd distractors is not appropriate in standardized test items.

6. **Avoid uncommon words or abbreviations**
   Uncommon words change the exam meaning of question and abbreviation can be interpreted differently. Always spell out the word. For instance: Which of the following **clot busters** is a **RI** (meaning *receptor inhibitor*).

7. **Your exam question should assess knowledge rather than memorization**
   Avoid a recall question such as: which of the following drugs is an antidiabetic agent. The result of this question does not tell you anything about how well a student knows about diabetes and its treatment.

8. **Do not rely on answers from previous questions**
   Different questions are built for different reasons. In addition, in standardized test, you will be able to see only one question at a time.

9. **Include 4-5 options for each question**
   Although there is no evidence-based data that indicates the more the answers are the better a question is, having 4-5 answers will minimize the "guessing credit".

10. **The question should assess one single idea**
    Although incorporation of related diseases into one question often assesses student's critical-thinking skills, incorporation of multiple ideas in an exam question makes the question confusing. For instance it is ok to write: A patient with a history of high blood glucose and high blood pressure has recently diagnosed with hypothyroidism. It is NOT ok to write: An injection dosage form that is used for emergency bradycardia has a pH of 6.5 and 0.9% NaCl with no antioxidant agent. Which of the following ingredients acts as an anticholinergic agent to treat bradycardia in an emergency setting?

11. Avoid ambiguities

Example: Which of the following antibiotics can influence the cell growth of bacteria (literally anything can influence a cell growth, even pure water in high amount).

12. Make it relevant

An exam question should be relevant to the material. It is ok to be related to the past material but not to the future or any material that has not yet been covered.

13. Assess, don't trick

Assess student knowledge retention not student's gambling skill.

14. Give it enough time

Student should have enough time to cope with an exam. An average of 1.5 min is needed for each MCQ. Calculation may need a little longer time.

15. Don't make it a habit

It is a natural tendency to put the right answer as C (in the middle), one has to be careful to not have many of these questions. In other words, randomly distribute the correct answer among the alternative choices throughout the examination.

16. Avoid double negative questions

Example: Which of the following drugs does NOT increase the serum's potassium level?
A. Loop diuretics do not increase serum's ion levels
B. …..

17. The exam questions should match the content of your topic.

In other words, if your topic is diabetes, your questions should not focus on infectious diseases.

18. Last but not least

Proofread, Proofread, Proofread. Always ask somebody else to review your exam questions/answers, there is always room for typos.